African swine fever in wild boar

EFSA Panel on Animal Health and Welfare (AHAW)

2018-07-18

EFSA Panel on Animal Health and Welfare (AHAW) , More , S & Sihvonen , L H 2018 , ' African swine fever in wild boar ' , EFSA Journal , vol. 16 , no. 7 , e05344 . https://doi.org/10.2903/j.efsa.2018.5344

http://hdl.handle.net/10138/298847
https://doi.org/10.2903/j.efsa.2018.5344

SCIENTIFIC OPINION

EFSA Journal

ADOPTED: 12 June 2018

doi: 10.2903/j.efsa.2018.5344

African swine fever in wild boar

EFSA Panel on Animal Health and Welfare (AHAW),
Simon More, Miguel Angel Miranda, Dominique Bicout, Anette Bøtner, Andrew Butterworth,
Paolo Calistri, Sandra Edwards, Bruno Garin-Bastuji, Margaret Good, Virginie Michel,
Mohan Raj, Søren Saxmose Nielsen, Liisa Sihvonen, Hans Spoolder, Jan Arend Stegeman,
Antonio Velarde, Preben Willeberg, Christoph Winckler, Klaus Depner, Vittorio Guberti,
Marius Masiulis, Edvins Olsevskis, Petr Satran, Mihaela Spiridon, Hans-Hermann Thulke,
Arvo Vilrop, Grzegorz Wozniakowski, Andrea Bau, Alessandro Broglia,
José Cortiñas Abrahantes, Sofie Dhollander, Andrey Gogin, Irene Muñoz Gajardo,
Frank Verdonck, Laura Amato and Christian Gortázar Schmidt

Abstract

The European Commission requested EFSA to compare the reliability of wild boar density estimates across the EU and to provide guidance to improve data collection methods. Currently, the only EU-wide available data are hunting data. Their collection methods should be harmonised to be comparable and to improve predictive models for wild boar density. These models could be validated by more precise density data, collected at local level e.g. by camera trapping. Based on practical and theoretical considerations, it is currently not possible to establish wild boar density thresholds that do not allow sustaining African swine fever (ASF). There are many drivers determining if ASF can be sustained or not, including heterogeneous population structures and human-mediated spread and there are still unknowns on the importance of different transmission modes in the epidemiology. Based on extensive literature reviews and observations from affected Member States, the efficacy of different wild boar population reduction and separation methods is evaluated. Different wild boar management strategies at different stages of the epidemic are suggested. Preventive measures to reduce and stabilise wild boar density, before ASF introduction, will be beneficial both in reducing the probability of exposure of the population to ASF and the efforts needed for potential emergency actions (i.e. less carcass removal) if an ASF incursion were to occur. Passive surveillance is the most effective and efficient method of surveillance for early detection of ASF in free areas. Following focal ASF introduction, the wild boar populations should be kept undisturbed for a short period (e.g. hunting ban on all species, leave crops unharvested to provide food and shelter within the affected area) and drastic reduction of the wild boar population may be performed only ahead of the ASF advance front, in the free populations. Following the decline in the epidemic, as demonstrated through passive surveillance, active population management should be reconsidered.

Keywords: African swine fever, wild boar, population density, population density threshold, population reduction, population separation, passive surveillance

Requestor: European Commission

Question number: EFSA-Q-2018-00141

Correspondence: ahaw@efsa.europa.eu

Panel members: Dominique Bicout, Anette Bøtner, Andrew Butterworth, Paolo Calistri, Klaus Depner, Sandra Edwards, Bruno Garin-Bastuji, Margaret Good, Christian Gortázar Schmidt, Virginie Michel, Miguel Angel Miranda, Simon More, Mohan Raj, Søren Saxmose Nielsen, Liisa Sihvonen, Hans Spoolder, Jan Arend Stegeman, Hans-Hermann Thulke, Antonio Velarde, Preben Willeberg and Christoph Winckler.

Acknowledgements: The Panel wishes to acknowledge all European competent institutions, Member State bodies and other organisations that provided data for this scientific output.

Suggested citation: EFSA AHAW Panel (EFSA Panel on Animal Health and Welfare), More S, Miranda MA, Bicout D, Bøtner A, Butterworth A, Calistri P, Edwards S, Garin-Bastuji B, Good M, Michel V, Raj M, Saxmose Nielsen S, Sihvonen L, Spoolder H, Stegeman JA, Velarde A, Willeberg P, Winckler C, Depner K, Guberti V, Masiulis M, Olsevskis E, Satran P, Spiridon M, Thulke H-H, Vilrop A, Wozniakowski G, Bau A, Broglia A, Cortiñas Abrahantes J, Dhollander S, Gogin A, Muñoz Gajardo I, Verdonck F, Amato L and Gortázar Schmidt C, 2018. Scientific Opinion on the African swine fever in wild boar. EFSA Journal 2018;16(7):5344, 78 pp. https://doi.org/10.2903/j.efsa.2018.5344

ISSN: 1831-4732

Summary

On 8 February 2018, the European Commission requested European Food Safety Authority (EFSA) to deliver a Scientific Opinion on African swine fever (ASF).

More in particular, the **first Term of Reference** asked to provide an estimate of the wild boar densities in the European Union (EU), to assess the reliability and comparability of the data and to propose possible guidance on a methodology to reach the best estimate.

The reliability and comparability of different methods to assess wild boar density were evaluated by wild boar ecologists from the EnetWild consortium. This assessment was mainly based on expert opinion and a narrative literature review. Brief guidelines were developed for measuring wild boar densities in a comparable and harmonised manner (ENETWILD et al., 2018).

Currently, some information on local wild boar density in Europe exists. However, it is difficult to access because it is mainly present in grey literature and collected with different methods. Therefore, as a proxy of wild boar density estimates, the maximum available numbers of wild boar hunted between 2014 and 2017 in the hunting grounds in the EU were provided, which are currently the only Europe-wide available data indicative of relative wild boar abundance. High quality and harmonised hunting data, however, would be required to make better use of data at large scale and for developing predicting models for wild boar density on a EU scale.

Precise density data can only be collected at local level (e.g. using camera trapping) although these data could also be used to validate large-scale abundance distribution models e.g. based on hunting data. Linking large-scale relative abundance estimates with local density data will provide the basis to produce validated, large-scale density maps.

The **second Term of Reference** requested to review the latest epidemiological data to identify threshold(s) in wild boar density that do not allow sustaining the disease, in different settings.

A short theoretical background section was provided about wild boar density thresholds for virus transmission in the different phases of an epidemic (introduction, spread and fade out). This was based on a narrative literature review. The epidemiological theory for density thresholds for sustaining infection is currently too simple to address the complex ecology of ASF. These theoretical approaches rely on key assumptions, including homogenous and random mixing of wild boar, which cannot be met.

From field observation, there is currently no indication that a density threshold exists for ASF. There are significant gaps in knowledge about the modes of ASF transmission including animal-to-animal transmission, indirect transmission from the contaminated environment or infected carcasses or the role of mechanical vectors in the ASF epidemiology.

Due to the complex ecology of ASF, other drivers apart from density may determine whether this disease can be sustained or not in a particular ecological setting. These could include indirect transmission from infected carcasses and the small-scale social structure of the host population.

Lessons learnt from the affected areas show that ASF spread has occurred in areas of varying, including very low, wild boar density. As yet, there is no evidence that the disease has disappeared from these areas. Furthermore, any derived density threshold would be difficult to translate into practical measures due to difficulty in estimating wild boar density *a priori*.

The **third Term of Reference** requested to review wild boar depopulation methods or population density reduction methods intended to achieve a determined threshold and rank them according to their efficacy, practical applicability in the EU, cost effectiveness and their capacity to minimise the spread of ASF.

As currently it is not possible to establish a density threshold for ASF, the effectiveness of any method that could potentially reduce wild boar density was evaluated. This evaluation was based on data extracted from scientific papers through an extensive literature review and from the lessons learnt from the affected Member States (MSs). Based on the available information, it was currently not possible, however, to rank the methods according to their efficacy, practical applicability or cost effectiveness.

Sus scrofa are called 'wild boar' in the areas where they are endemic and 'feral pigs' in the areas where they are invasive. Generally, control efforts to reduce feral pigs have been more rigorously implemented, often backed up by a different legal background and public attitude. Therefore, distinction between the two has been made throughout this Opinion.

Locally implemented emergency measures for disease control should be distinguished from long-term interventions at larger scale aiming at sustainable population management e.g. through recreational hunting. The literature review concluded that recreational hunting of wild boar and feral swine can be effective as a regulatory measure to keep ASF-free populations stable, but biased hunting preferences

towards large males and the feeding of wild boar should be avoided. Hunting efforts should be maintained in intensity (harvest rate > 67% per year) to stabilise wild boar populations.

In the context of disease control, depopulation of wild boar has been achieved in small, fenced estates, but in larger areas, not more than 50% population reduction was reported. In areas of high habitat quality, maintaining an intense wild boar population control over a prolonged period of time through intervention is expensive and possibly not sustainable in the long term.

Eradication of insular feral swine populations has been achieved on some occasions only through years of intense drive hunting with dogs, with or without the use of other methods such as trapping or shooting from helicopters. In focal feral swine populations, drastic reduction has been reported with up to 80% in control programmes implementing shooting from helicopters or a combination of trapping and intense drive hunting with dogs. Recovery of the population with up to 77% in the year after has been reported and control programmes should be carried out over several years to obtain sustainable reduction of feral swine.

The use of traps has resulted in a harvest of 79% of the population and can be especially interesting in areas where hunting is not recommended.

The parental use of a gonadotropin-releasing hormone (GnRH) immune-contraceptive vaccine has demonstrated promising results to reduce the fertility of feral swine kept under experimental conditions. Research is needed, however, to investigate the presence of potential residues of GnRH in meat and the possibility to develop a vaccine that could be administered orally in a selective way, to minimise bait uptake by non-target species.

Poisoning of wild boar is forbidden in the EU under the legislation of biodiversity conservation. However, poisoning has been demonstrated as highly efficient in reducing feral swine populations. The potential undesirable effects, including welfare aspects of administering the poison and the possible effects of its residues on the health of humans and animals through direct or indirect exposure have not been sufficiently investigated in the European context.

Based on experiences in the MSs, it is not possible to rank the effectiveness of the individual measures applied. The current understanding is that only the combination of measures applied in the Czech Republic resulted in very limited spread from the first detection of ASF in wild boar for less than half a year.

Different actions in terms of wild boar management at different stages of the epidemic are suggested based on the collective experience of the affected MS:

Preventive measures taken to reduce wild boar density will be beneficial both in reducing the probability of exposure of local population to African swine fever virus (ASFV) and reducing the efforts needed for potential emergency actions (i.e. less carcass removal) if an ASF incursion was subsequently to occur.

Following focal introduction, emergency measures should focus on drastic reduction in the wild boar population ahead of the ASF advance front, in the free populations and management of the infected population solely to keep it undisturbed and avoid aggregation of individuals and avoid any spread (e.g. hunting ban, including also hunting on other species, leaving crops unharvested within the affected area) is proposed.

Following the decline in the epidemic, as demonstrated through passive surveillance, active population management could be reconsidered.

The efficacy of these measures could be jeopardised by the continuous introduction of ASV from neighbouring affected areas or through human mediated spread.

The **fourth Term of Reference** requested to review fencing methods, or population separation methods, available for wild boar in different scenarios and for different objectives. Therefore, the effectiveness of the different methods used for separating wild boar was evaluated based on information found in scientific literature, through an extensive review. Additionally, the information available from the affected MS, on the effect of physical or natural barriers on ASF spread in wild boar populations was provided and discussed.

From the extensive literature review, it could be concluded that some electrical fences have demonstrated ability to temporarily protect crops from damage caused by wild boar or feral swine with different levels of efficiency, but no electrical fence design can be considered 100% wild boar proof on a large scale for a prolonged period of time.

Odour repellents have been tested to keep away wild boar and feral swine from crops with divergent results. Five trials could not demonstrate any effect of the repellent on wild boar or feral swine intrusion or on crop damage, while two trials reported damage reduction by wild boar ranging from 55% to 100% and from 26% to 43%.

Light repellent did not show any significant effect on the probability of wild boar visiting luring sites. Sound repellents have been reported to reduce 67% of crop damage caused by wild boar.

Currently, there is no evidence that large fences have been effective for the containment of wild suids. Some new large-scale fences are under construction, and their effectiveness to separate wild boar populations will need to be evaluated in the future.

Natural barriers such as large rivers or straits can be used for demarcation for restricted areas as they have shown to reduce, but not completely impede, the movements of wild boar.

The **fifth Term of Reference** requested to propose and assess a surveillance strategy, provide sample size, frequency of sampling and identify possible risk groups for early detection of ASF in a naive wild boar population. This section was based on a narrative review and concluded that in countries free of infection, the primary surveillance objective is early detection. Once infection occurs, the objective shifts to estimating the prevalence of infection and case finding while, following elimination, the surveillance objective shifts back to early detection and demonstrating freedom of infection.

Passive surveillance is the most effective and efficient method of surveillance for early detection of ASF in wild boar. For early detection through passive surveillance, the aim is to test as many ‘found dead’ animals as possible. Based on current knowledge and experiences, for an intervention to be successful, there is a need to detect an ASF incursion while it is still spatially contained.

In uninfected populations, there is a need for estimates of wild boar density and normal mortality rates combined with the probability of detecting a ‘found dead’ animals given its presence. This information could be used to validate the submission rate (i.e. the numbers of wild boar that should be submitted due to natural mortality).

The **sixth Term of Reference** requested to review successful and relevant methodologies used in the past for surveillance programmes in wildlife and identify successful strategies for ensuring the optimal involvement of the main stakeholders. As passive surveillance is the most effective for early detection, positive experiences gained by the ASF-affected MS with passive surveillance programmes were summarised. Successful strategies for ensuring the optimal involvement of the main stakeholders were identified. Enhanced passive surveillance of ASF in wild boar populations demands a continuous dialogue between all involved stakeholders and a shared responsibility in monitoring and control of the disease. Continuous awareness building, incentives and good collaboration with the hunters are essential.

Table of contents

1. Introduction

1.1. Background and Terms of Reference as provided by the requestor

African swine fever (ASF) is an exotic disease that requires a multisectorial approach to be addressed in an effective manner. The presence of this infection in the Eurasian wild boar (*S. scrofa*) population represents a challenge for the EU that requires some specific tailor-made measures. Some specific knowledge already exists and several areas still need to be further explored. The experiences gained in the EU and outside the EU in managing wild boar populations should be reviewed to identify the tools which are most suitable for the EU scenario.

There is knowledge, legislation, technical and financial tools in the EU to properly face ASF. The main pieces of the EU legislation relevant for ASF have been reviewed in the Commission request for a scientific and technical assistance on African swine fever issued on 1 December 2017.

In addition, an ASF Strategy for the Eastern Part of the EU has been developed based on earlier scientific recommendations by EFSA. This strategy is constantly evolving based on new science available and on new experiences gained.

The current wild boar density in the EU appears to facilitate the onset of ASF and its maintenance *de facto* creating a reservoir for this virus. As indicated in the 2015 EFSA opinion on ASF a reduction of the wild boar density to a certain threshold would bring about a basic reproduction rate for ASF lower than one, leading to the self-extinguishment of the disease in the wild boar meta populations. Any update on what information is available to identify this wild boar density level would be helpful. However this information needs to be contextualised within the limits of the current methods of assessing wild boar densities in the EU.

As recommended in the 2015 EFSA opinion on ASF and the subsequent technical reports, there are several ways to approach wild boar population control. While advantages and disadvantages of hunting have already been assessed, further assessment is needed of other methods to control wild boar population and movements to provide the competent authorities with a broader set of tools to be applied in the field.

Surveillance for ASF in wild boar in the EU is broadly based on passive surveillance. Such an approach should be reviewed against other surveillance methodologies allowing for early detection of the occurrence of ASF in a naïve wild population. Reviewing key aspects used in other wildlife surveillance programmes in the past would be helpful to ensure that the main stakeholders contribute in an optimal manner.

Therefore, in the context of Article 29 of Regulation (EC) No 178/2002, EFSA should provide a Scientific Opinion to the Commission based on the following Terms of Reference (TOR):

1) Provide an estimate of the wild boar densities in the EU and assess the reliability and comparability of the data; propose possible guidance on a methodology to reach the best estimate.
2) Review the latest epidemiological data to identify threshold(s) in wild boar density which do not allow sustaining the disease, in different settings.
3) Review the wild boar depopulation methods, or population density reduction methods intended to achieve a determined threshold, (e.g. poisoning, selective killing and chemical sterilisation) and rank them according to their efficacy, practical applicability in the EU, cost-effectiveness and their capacity to minimise the spread of African swine fever.
4) Review the fencing methods, or population separation methods, available for wild boar (e.g. permanent, electric, odour) in the EU in different scenarios (e.g. forest, farmland, urban area) and for different objectives (e.g. for preventing movement of wild boar) while keeping in mind the wild boar ecology.
5) Considering the wild boar densities identified in ToR 1 and the risk of introduction of African swine fever in naïve wild boar population in the EU, propose and assess a surveillance strategy, provide sample size, frequency of sampling and identify possible risk groups. This surveillance needs to be prioritised for early detection of disease introduction and cost effectiveness.
6) Review of successful and relevant methodologies used in the past for surveillance programmes in wildlife and identify successful strategies for ensuring the optimal involvement of the main stakeholders.

1.2. Interpretation of the Terms of Reference

After the request from the European Commission for a scientific and technical assistance on ASF issued on 1 December 2017 (M-2017-0217), European Food Safety Authority (EFSA) will prepare two reports analysing the latest ASF epidemiological data and assessing disease management options of domestic pigs and wild boar in the ASF-affected countries. These reports will be ready for approval in November 2018 (question number EFSA-Q-2017-00823) and November 2019 (question number EFSA-Q-2018-00053).

Some general background information about ASF, including an update on the geographic distribution, the impact on animal health, modes of transmission, a summary of known information on potential vectors and their distribution and some information about the diagnosis can be found in EFSA's storymap on ASF.

Therefore, this Scientific Opinion will not provide background information on ASF nor will it provide an update on the epidemiological situation in the affected Member State (MS), as this information will be available in the above-mentioned reports or can be consulted in the EFSA storymap on ASF. The ToR are addressed as follows:

ToR 1 requested wild boar density estimates across the European Union Member State (EU MS). Currently, there are no harmonised data pertaining density of wild boar in the different hunting grounds of the EU MS, and therefore, the numbers of wild boar harvested (the relative abundance) between 2014 and 2017 were collected in a harmonised way and mapped as a proxy of the wild boar density. The reliability of relative abundance of wild boar was discussed as well as the comparability with data obtained through other methods. Brief guidance on different methodologies to obtain wild boar density estimates was provided by wild boar ecologists in an External Scientific Report provided to EFSA (ENETWILD et al., 2018).

ToR 2 requested epidemiological data to identify wild boar density thresholds that do not allow sustaining of ASF. A short theoretical section was provided about wild boar density thresholds for any pathogen transmission and the difficulties in estimating a density threshold for African swine fever virus (ASFV) transmission in wild boar populations were elaborated. Some tangential observations from the field demonstrating these difficulties were also provided.

ToR 3 requested a review of wild boar depopulation methods or population density reduction methods intended to achieve a determined density threshold and to rank them. As currently it is not possible to establish a density threshold (the outcome of ToR2), the effectiveness of any method that could potentially reduce the wild boar density was evaluated. This evaluation was based on data extracted from scientific papers through an extensive literature review and from the lessons learnt in the affected MS. It was currently not possible, however, to rank the methods according to their efficacy, practical applicability or cost effectiveness based on the available information.

ToR 4 requested a review of fencing methods, or population separation methods, available for wild boar in different scenarios and for different objectives. Therefore, the effectiveness of the different methods used for separating wild boar was evaluated based on information found in scientific literature, through an extensive review. Additionally, the information available from the affected MS, on the effect of physical or natural barriers on ASF spread in wild boar populations was provided and discussed.

ToR 5 requested to propose and assess a surveillance strategy, to provide sample size, frequency of sampling and to identify possible risk groups in a naive wild boar population for early detection of ASFV introduction, taking into account the cost effectiveness of the surveillance methods. To address this ToR, the role of passive and active surveillance in the different stages of the epidemic was explained and evidence was provided that passive surveillance is the most appropriate approach for early detection of ASF.

ToR 6 requested a review of successful and relevant methodologies used in the past for surveillance programmes in wildlife and to identify successful strategies for ensuring the optimal involvement of the main stakeholders. As passive surveillance is the most effective for early detection of ASF (outcome of ToR 5), the experiences gained by the ASF affected MS with the passive surveillance programmes implemented in their affected wild boar populations or populations at risk were summarised and successful strategies for ensuring the optimal involvement of the main stakeholders were identified.

2. Data and methodologies

2.1. Data

2.1.1. Numbers of harvested wild boar per hunting ground

2.1.1.1. Numbers of harvested wild boar per hunting ground

Data on the maximum available numbers of wild boar harvested between 2014 and 2017 in the hunting grounds of the EU MSs were collected through EnetWild's wild boar data model (WBDM) (http://www.enetwild.com/data-repository/).

2.1.1.2. Efficacy of wild boar population reduction and separation measures

Data on the efficacy of measures applied to reduce or separate wild boar populations were extracted from published scientific papers during an extensive literature review (see Appendix A).

2.2. Methodologies

2.2.1. Wild boar density (ToR 1)

2.2.1.1. Numbers of harvested wild boar per hunting ground

As a proxy of wild boar density estimates, the numbers of wild boar harvested in 2017 in the hunting grounds of the EU MSs were provided and were mapped using ArcGiS software (ESRI). The underlying data are provided in the data repository of EnetWild.

Estimates of wild boar hunting bags trends were calculated using version 3.54 of the TRIM (TRends and Indices for Monitoring data) software package (Pannekoek and Van Strien 2001). TRIM estimates annual counts with missing observation by fitting a generalised linear model with Poisson errors and logarithmic link (McCullagh and Nelder 1989; Pannekoek and Van Strien 2001).

The linear trend model was used with all years as change points and all models were run with serial correlation and overdispersion was taken into account. Yearly indices and an overall trend estimate are presented in Section 3.1.2.2. The annual index uses the first-year arbitrarily set at one and each annual index was calculated in relation to the first, standardising population trends.

2.2.1.2. Reliability and comparability of wild boar density estimation methods

The reliability (i.e. the extent to which the various measures to estimate wild boar density relate to

more rigorously implemented, often backed up by a different legal background and public attitude.

- Recreational hunting of wild boar and feral swine can be effective as a regulatory measure to keep ASF-free populations stable, but biased hunting preferences towards large males and feeding of wild boar should be avoided. Hunting efforts should be increased in intensity (harvest rate > 67% per year) to stabilise wild boar populations.
- Urgent interventions for disease control (i.e. locally implemented emergency measures) should be distinguished from long-term management at larger scale aiming at sustainable population management.
- In the context of disease control, depopulation of wild boar has been achieved in small, fenced estates, but in larger areas, not more than 50% of population reduction was reported.
- In areas of high habitat quality, maintaining an intense wild boar population control over a prolonged period of time through intervention is expensive and possibly not sustainable in the long term.
- Eradication of insular feral swine populations has been achieved on some occasions only, through years of intense drive hunting with dogs, with or without the use of other methods such as trapping or shooting from helicopters.
- Drastic reduction (up to 80%) of feral swine populations has been reported with control programmes implementing shooting swine from a helicopter or a combination of trapping and intense drive hunting with dogs. Recovery of the population up to 77% the year after has been reported.
- The use of traps has resulted in a harvest of wild boar up to 79% of the population and can be especially interesting in areas where hunting is not recommended.
- The parenteral use of a GnRH immune-contraceptive vaccine has been demonstrated to reduce the fertility of feral swine kept under experimental conditions. Research is needed, however, to investigate the presence of potential residues of GnRH in meat and the possibility to develop a vaccine that could be administered orally in a selective way to avoid non-target species.
- Poisoning of wild boar is forbidden in the EU under the legislation of biodiversity conservation. However, poisoning has been demonstrated as highly efficient in reducing local feral swine populations. The potential undesirable effects, including welfare aspects of administering the poison and the possible effects of its residues on the health of humans and animals through direct or indirect exposure, have not been sufficiently investigated in the European context.

Field experience

- Based on experiences in the MSs, it is not possible to rank the effectiveness of the individual measures applied. The combination of measures applied in the Czech Republic is the only one where spread only over a short distance was reported up to less than half a year after the first ASF case in wild boar was detected.
- Different actions in terms of wild boar management at different stages of the epidemic are reported based on the collective experience of the affected MS:
- Preventive: measures taken to reduce wild boar density will be beneficial both in reducing the probability of exposure of local population to ASFV and reducing the efforts needed for potential emergency actions (i.e. less carcass removal) if an ASF incursion was subsequently to occur.
- Following focal introduction: drastic reduction in the wild boar population ahead of the ASF advance front (in the free population), and management of the infected population solely to keep it undisturbed and avoid aggregation of individuals and avoid any spread (e.g. short-term hunting ban of wild boar and other species or leaving crops unharvested within the affected area).
- Following the decline in the epidemic, as demonstrated through passive surveillance, active population management could be reconsidered.
- The efficacy of these measures can be jeopardised by the continuous introduction of ASV from neighbouring affected areas or through human-mediated spread.

4.4. Review of wild boar separation methods (TOR4)

Extensive literature review

- Some electrical fences have been demonstrated to temporarily protect crops from damage caused by wild boar or feral swine with different levels of efficiency, but no electrical fence

design can be considered 100% wild boar proof on a large scale for a prolonged period of time. Fences have been shown to be more effective if wild boar are not disturbed by drastic hunting such as drive hunts with dogs, which increase the movement of wild boar and their urge to escape.
- Odour repellents have been tested to keep away wild boar and feral swine from crops with divergent results.
- Light repellent did not show any significant effect on the probability of wild boar visiting luring sites according to two studies.
- Sound repellents have been shown reported to reduce 67% of crop damage caused by wild boar according to one study.

Field experience

- Currently, there is no evidence that large fences have been effective for the containment of wild suids. Some new large-scale fences are under construction, and their effectiveness to separate wild boar populations will need to be evaluated in the future.
- Natural barriers such as large rivers or straits can be used for demarcation for restricted areas as they have shown to reduce, but not completely impede, the movements of wild boar.

4.5. Wild boar surveillance strategy (ToR5)

- In countries free of infection, the primary surveillance objective is early detection. Once infected, the objective shifts to case finding and estimating the prevalence. Following elimination, the surveillance objective shifts back to early detection and demonstrating freedom of infection.
- Passive surveillance is the most effective and efficient method of surveillance for early detection of ASF in wild boar. For early detection through passive surveillance, the aim is to test as many 'found dead' animals as possible.
- In uninfected populations, there is a need for estimates of wild boar density and mortality rate combined with the probability of detecting 'found dead' animals given its presence. This information could be used to validate the submission rate (i.e. the numbers of wild boar that should be submitted due through natural mortality).
- Based on current knowledge and experiences, for an intervention to be successful, there is a need to detect an ASF incursion while it is still spatially contained.

4.6. Optimising involvement of stakeholders in passive surveillance of wild boar (ToR6)

- All MS stated that awareness building and a good collaboration with the hunters were important, although the effect could not be qualified.
- Reporting of carcasses was strongly linked in time with the start of the incentives.
- Incentives helped in reporting carcasses, but experienced people should be involved in the sampling and removal of carcasses.
- Incentives paid for finding carcasses helped especially in newly infected areas, as many carcasses could be found. However, in the later stages, when fewer carcasses can be found, incentives for organised searching events can be more effective.
- A whole range of other measures was applied, but their impact was not quantified.

5. Recommendations

- To improve the quality of hunting data, parameters such as the surface covered, numbers of wild boar shot along with data on the hunting effort are needed across Europe.
- Any attempt to control wild boar populations should be carried out over several years to obtain sustainable reduction.
- Wild boar feeding should be prohibited in unfenced wild boar populations.

References

Acevedo P, Quirós-Fernández F, Casal J and Vicente J, 2014. Spatial distribution of wild boar population abundance: basic information for spatial epidemiology and wildlife management. Ecological Indicators, 36, 594–600. https://doi.org/10.1016/j.ecolind.2013.09.019

Alexandrov T, Kamenov P, Stefanov D and Depner K, 2011. Trapping as an alternative method of eradicating classical swine fever in a wild boar population in Bulgaria. Revue Scientifique Et Technique-Office International Des Epizooties, 30, 911–916.

Anderson SJ and Stone CP, 1993. Snaring to control feral pigs *Sus-scrofa* in a remote Hawaiian rain-forest. Biological Conservation, 63, 195–201.

Barasona JA, Acevedo P, Diez-Delgado I, Queiros J, Carrasco-García R, Gortazar C and Vicente J, 2016. Tuberculosis-associated death among adult Wild Boar, Spain, 2009–2014. Emerging Infectious Diseases, 22, 2178–2180. https://doi.org/10.3201/eid2212.160677

Barron MC, Anderson DP, Parkes JP and Gon III SMO, 2011. Evaluation of feral pig control in Hawaiian protected areas using Bayesian catch-effort models. New Zealand Journal of Ecology, 35, 182–188.

Bil M, Andrasik R, Bartonicka T, Krivankova Z and Sedonik J, 2018. An evaluation of odor repellent effectiveness in prevention of wildlife-vehicle collisions. Journal of Environmental Management, 205, 209–214.

Boadella M, Barasona JA, Pozio E, Montoro V, Vicente J, Gortazar C and Acevedo P, 2012a. Spatio-temporal trends and risk factors for *Trichinella* species infection in wild boar (*Sus scrofa*) populations of central Spain: a long-term study. International Journal for Parasitology, 42, 739–745.

Boadella M, Vicente J, Ruiz-Fons F, de la Fuente J and Gortazar C, 2012b. Effects of culling Eurasian wild boar on the prevalence of Mycobacterium bovis and Aujeszky's disease virus. Preventive Veterinary Medicine, 107, 214–221. https://doi.org/10.1016/j.prevetmed.2012.06.001

Boitani L, Trapanese P and Mattei L, 1995. Methods of population estimates of a hunted wild boar (Sus scrofa L.) population in Tuscany (Italy). IBEX J. Mt. Ecol., 3, 204–208.

Bonet-Arboli V, Llimona F, Pla A, Rafart-Plaza E, Padros J and Rodriguez-Teijeiro JD, 2000. Evolution of wild boar (*Sus scrofa*) hunting in Collserola Park. First meeting on research on the natural systems of Collserola: applications to the management of the park. pp. 225–232.

Burt MD, Miller C and Souza D, 2011. The use of volunteer hunting as a control method for feral pig populations on O'ahu. Hawaii. Occasional Papers of the IUCN Species Survival Commission, 42, 402–406.

Cellina S, 2008. Effects of supplemental feeding on the body condition and reproductive state of wild boar *Sus scrofa* in Luxembourg. Ph.D. Thesis, University of Sussex, Brighton, UK.

Cowled BD, Gifford E, Smith M, Staples L and Lapidge SJ, 2006. Efficacy of manufactured PIGOUT (R) baits for localised control of feral pigs in the semi-arid Queensland rangelands. Wildlife Research, 33, 427–437.

Dakpa P, Penjore U and Dorji T, 2009. Design, fabrication and performance evaluation of wild pig repellent device. Journal of Renewable Natural Resources Bhutan, 5, 116–126.

Deredec A and Courchamp F, 2003. Extinction threshold in host-parasite dynamics. Annales Zoologi Fennici, 40, 115–130.

Ditchkoff SS, Holtfreter RW and Williams BL, 2017. Effectiveness of a bounty programme for reducing wild pig densities. Wildlife Society Bulletin, 41, 548–555.

ECHA (European Chemicals Agency), 2009. Directive 98/8/EC concerning the placing of biocidal products on the market. Warfarin (PT 14) Assessment Report, 2009. P61 Available online: http://dissemination.echa.europa.eu/Biocides/ActiveSubstances/0056-14/0056-14_Assessment_Report.pdf

ENETWILD Consortium, Keuling O, Sange M, Acevedo P, Podgorski T, Smith G, Scandura M, Apollonio M, Ferroglio E, Body G and Vicente J, 2018. Guidance on estimation of wild boar population abundance and density: methods, challenges, possibilities. EFSA supporting publication 2018;EN-1449. 48 pp. https://doi.org/10.2903/sp.efsa.2018.EN-1449

EFSA AHAW Panel (EFSA Panel on Animal Health and Welfare), 2011. Scientific opinion on bluetongue monitoring and surveillance. EFSA Journal 2011;9(6):2192, 61 pp. https://doi.org/10.2903/j.efsa.2011.2192

EFSA AHAW Panel (EFSA Panel on Animal Health and Welfare), 2015. Scientific opinion on African swine fever. EFSA Journal 2015;13(7):4163, 92 pp. https://doi.org/10.2903/j.efsa.2015.4163

Eisler R (Patuxent Environmental Science Center, US National Biological Service), 1995. Sodium monofluoroacetate (1080) hazards to fish, wildlife, and invertebrates: a synoptic review. Contaminant Hazard Reviews, 52 pp. Available online: https://www.pwrc.usgs.gov/eisler/CHR_30_Sodium_monofluoroacetate.pdf

Engeman R, Hershberger T, Orzell S, Felix R, Killian G, Woolard J, Cornman J, Romano D, Huddleston C, Zimmerman P, Barre C, Tillman E and Avery M, 2014. Impacts from control operations on a recreationally hunted feral swine population at a large military installation in Florida. Environmental Science and Pollution Research, 21, 7689–7697.

Garcia-Jimenez WL, Fernandez-Llario P, Benitez-Medina JM, Cerrato R, Cuesta J, Garcia-Sanchez A, Goncalves P, Martinez R, Risco D, Salguero FJ, Serrano E, Gomez L and Hermoso-de-Mendoza J, 2013. Reducing Eurasian wild boar (*Sus scrofa*) population density as a measure for bovine tuberculosis control: effects in wild boar and a sympatric fallow deer (*Dama dama*) population in Central Spain. Preventive Veterinary Medicine, 110, 435–446.

Geisser H and Reyer HU, 2004. Efficacy of hunting, feeding and fencing to reduce crop damage by wild boar. Journal of Wildlife Management, 68, 939–946.

Gentle M and Pople A, 2013. Effectiveness of commercial harvesting in controlling feral-pig populations. Wildlife Research, 40, 459–469.

Gioeli KT, Munyan S, Adams L, Huffman J, Russakis E and Vachon E, 2015. 4-H southern swines feral hog challenge. Journal of Extension, 53, 4IAW7.

Hafeez S, Khan ZH, Khan RA, Qadir I and Rashid F, 2007. Comparative efficacy of some trap for controlling porcupines, wild boar and other vertebrate pests. Pakistan Journal of Agricultural Sciences, 44, 150–153.

Hone J and Stone CP, 1989. A comparison and evaluation of feral pig management in two national-parks. Wildlife Society Bulletin, 17, 419–425.
Jeyasingh PD and Davidar P, 2003. Crop depredation by wildlife along the eastern boundary of the Kalakad-Mundanthurai Tiger Reserve, southern India. Journal of the Bombay Natural History Society, 100, 38–45.
Ježek M, Holá M, Kušta T and Červený J, 2016. Creeping into a wild boar stomach to find traces of supplementary feeding. Wildlife Research, 43, 590–598. https://doi.org/10.1071/WR16065
Katahira LK, Finnegan P and Stone CP, 1993. Eradicating feral pigs in montane mesic habitat at Hawaii-volcanos-national-park. Wildlife Society Bulletin, 21, 269–274.
Keuling O, Baubet E, Duscher A, Ebert C, Fischer C, Monaco A, Podgórski T, Prevot C, Ronnenberg K, Sodeikat G, Stier N and Thurfjell H, 2013. Mortality rates of wild boar *Sus scrofa* L. in central Europe. European Journal of Wildlife Research, 59, 805–814.
Killian G, Miller L, Rhyan J and Doten H, 2006. Immunocontraception of Florida feral swine with a single-dose GnRH vaccine. American Journal of Reproductive Immunology, 55, 378–384.
Lavelle MJ, Vercauteren KC, Hefley TJ, Phillips GE, Hygnstrom SE, Long DB, Fischer JW, Swafford SR and Campbell TA, 2011. Evaluation of fences for containing feral swine under simulated depopulation conditions. Journal of Wildlife Management, 75, 1200–1208.
Leránoz I and Castién E, 1996. Evolution of wild boar (Sus scrofa L., 1758) in Navarra (N Iberian peninsula). Miscellania Zoologica, 19, 133–139.
Lloyd-Smith JO, Cross PC, Briggs CJ, Daugherty M, Getz WM, Latto J, Sanchez M, Smith AB and Swei A, 2005. Should we expect population thresholds for wildlife diseases? Trends in Ecology and Evolution, 20, 511–519.
Massei G, Kindberg J, Licoppe A, Gacic D, Šprem N, Kamler J, Baubet E, Hohmann U, Monaco A, Ozolinš J, Cellina S, Podgórski T, Fonseca C, Markov N, Pokorny B, Rosellp C and Náhlikq A, 2015. Wild boar populations up, numbers of hunters down? A review of trends and implications for Europe. Pest Management Science, 71, 492–500. https://doi.org/10.1002/ps.3965
McCallum H, Barlow N and Hone J, 2001. How should pathogen transmission be modelled? Trends in Ecology and Evolution, 16, 295–300.
McCullagh P and Nelder JA, 1989. Generalized Linear Models, 2nd Edition.Chapman & Hall, London.
McCann BE and Garcelon DK, 2008. Eradication of feral pigs from Pinnacles National Monument. Journal of Wildlife Management, 72, 1287–1295.
McIlroy JC and Gifford EJ, 1997. The 'Judas' pig technique: a method that could enhance control programmes against feral pigs, *Sus scrofa*. Wildlife Research, 24, 483–491.
McIlroy JC and Saillard RJ, 1989. The effect of hunting with dogs on the numbers and movements of feral pigs, *Sus scrofa*, and the subsequent success of poisoning exercises in Namadgi National Park, A.C.T. Australian Wildlife Research, 16, 353–363.
McIlroy JC, Braysher M and Saunders GR, 1989. Effectiveness of a warfarin-poisoning campaign against feral pigs, *Sus scrofa*, in Namadgi National Park, A.C.T. Australian Wildlife Research, 16, 195–202. https://doi.org/10.1071/WR9890195
Monzon A and Bento P, 2004. An analysis of the hunting pressure on wild boar (*Sus scrofa*) in the Trás-os-Montes region of northern Portugal. Galemys, 16, 253–272.x
Morters MK, Restif O, Hampson K, Cleaveland S, Wood JL and Conlan AJK, 2013. Evidence-based control of canine rabies: a critical review of population density reduction. Journal of Animal Ecology, 82, 6–14. https://doi.org/10.1111/j.1365-2656.2012.02033
Pannekoek J and van Strien A, 1998. TRIM 2.0 for Windows (Trends & Indices for Monitoring data). Statistics Netherlands, Voorburg.
Pejsak Z, Truszczynski M, Niemczuk K, Kozak E and Markowska-Daniel I, 2014. Epidemiology of African swine fever in Poland since the detection of the first case. Polish Journal Veterinary Science, 17, 665–672. https://doi.org/10.2478/pjvs-2014-0097
Piechowski D, 1996. Field trials on efficiency of odour repellent - Duftzaun in game deterring. Sylwan, 140, 49–60.
Podgórski T, Apollonio M and Keuling O, 2018. Contact rates in wild boar populations: implications for disease transmission. Journal of Wildlife Management, 341, 517.
Pol F, Rossi S, Mesplède A, Kuntz-Simon G and Le Potier M, 2008. Two outbreaks of classical swine fever in wild boar in France Veterinary Record, 162, 811–816.
Quirós-Fernández F, Marcos J, Acevedo P and Gortazar C, 2017. Hunters serving the ecosystem: the contribution of recreational hunting to wild boar population control. European Journal of Wildlife Research, 63, 57. https://doi.org/10.1007/s10344-017-1107-4
Reidy MM, Campbell TA and Hewitt DG, 2008. Evaluation of electric fencing to inhibit feral pig movements. Journal of Wildlife Management, 72, 1012–1018.
Reidy MM, Campbell TA and Hewitt DG, 2011. A mark-recapture technique for monitoring feral swine populations. Rangeland Ecology and Management, 64, 316–318.
Rossi S, Staubach C, Blome S, Guberti V, Thulke HH, Vos A, Koenen F and Le Potier MF, 2015. Controlling of CSFV in European wild boar using oral vaccination: a review. Frontiers in Microbiology, 6, 1141. https://doi.org/10.3389/fmicb.2015.01141

Sakthivel Rao AMKM, Rao NS and Reddy P, 2013. Efficacy of non poisonous castor based repellent against wild boar (*Sus scrofa*) in maize crop around Hyderabad. Pestology, 37, 26–29.
Santilli F and Stella RMD, 2006. Electrical fencing of large farmland area to reduce crops damages by wild boar *Sus scrofa*. Agricoltura Mediterranea, 136, 79–84.
Sapkota S, Aryal A, Baral SR, Hayward MW and Raubenheimer D, 2014. Economic analysis of electric fencing for mitigating human-wildlife conflict in Nepal. Journal of Resources and Ecology, 5, 237–243.
Saunders G, 1993. Observations on the effectiveness of shooting feral pigs from helicopters. Wildlife Research, 20, 771–776.
Saunders G, Kay B and Nicol H, 1993. Factors affecting bait uptake and trapping success for feral pigs (*Sus scrofa*) in Kosciusko National-Park. Wildlife Research, 20, 653–665.
Schlageter A and Haag-Wackernagel D, 2011. Effectiveness of solar blinkers as a means of crop protection from wild boar damage. Crop Protection, 30, 1216–1222.
Schlageter A and Haag-Wackernagel D, 2012a. A gustatory repellent for protection of agricultural land from wild boar damage: an investigation on effectiveness. Journal of Agricultural Science (Toronto), 4, 61–68.
Schlageter A and Haag-Wackernagel D, 2012b. Evaluation of an odor repellent for protecting crops from wild boar damage. Journal of Pest Science, 85, 209–215.
Schmidt A, 1986. Wild boar control with electric fences - experiences of an effective method for the protection of young coconut plantations. Oleagineux, 41, 557–559.
Schnyder M, Stark KDC, Vanzetti T, Salman MD, Thur B, Schleiss W and Griot C, 2002. Epidemiology and control of an outbreak of classical swine fever in wild boar in Switzerland. Veterinary Record, 150, 102–109.
Snow NP, Foster JA, Kinsey JC, Humphrys ST, Staples LD, Hewitt DG and VerCauteren KC, 2017. Development of toxic bait to control invasive wild pigs and reduce damage. Wildlife Society Bulletin, 41, 256–263.
Thulke HH, Eisinger D, Freuling C, Fröhlich A, Globig A, Grimm V, Müller T, Selhorst T, Staubach C and Zips S, 2009. Situation-based surveillance: adapting investigations to actual epidemic situations. Journal of Wildlife Diseases, 45, 1089–1103. https://doi.org/10.7589/0090-3558-45.4.1089
Twigg LE, Lowe T, Martin G and Everett M, 2005. Feral pigs in north-western Australia: basic biology, bait consumption and the efficacy of 1080 baits. Wildlife Research, 32, 281–296.
Vidrih M and Trdan S, 2008. Evaluation of different designs of temporary electric fence systems for the protection of maize against wild boar (*Sus scrofa* L., Mammalia, Suidae). Acta Agriculturae Slovenica, 91, 343–349.
Wegorek P and Giebel J, 2008. The effectiveness of selected active substances in keeping away wild boar (*Sus scrofa* L.) from feeding on maize crops. Progress in Plant Protection, 48, 1002–1006.
Wegorek P, Zamojska J, Bandyk A and Olejarski P, 2014. Results of the monitoring of the effectiveness of repellents against wild boar in the fields. Progress in Plant Protection, 54, 159–162.

Glossary and Abbreviations

AHAW Panel	EFSA Panel on Animal Health and Welfare
ASF-affected area	area delineated by confirmed cases of ASF-infected wild boar or domestic pigs
ASF-infected area	area as defined in Commission Implementing Decision of 9 October 2014 (2014/709/EU) (as latest amended by Commission Implementing Decision (EU) 2018/478 of 20 March 2018)
Relative wild boar abundance	index that correlates with density but that does not establish number of wild boar per surface, for instance the annual hunting bag
Wild boar density	number of wild boar individuals per unit of surface (syn. census)
ASF	African swine fever
ASFV	African swine fever virus
CCS	Critical community size
CI	Confidence interval
CSF	Classical swine fever
GnRH	gonadotropin-releasing hormone
LD_{50}	lethal dose, 50%
LEDs	light-emitting diodes
MS	Member State
NRL	National Reference Laboratory
PCR	polymerase chain reactrion
TB	tuberculosis
ToR	Term of Reference
WVC	Wildlife-vehicle collisions
WBDM	Wild Boar Data Model

Appendix A – Extensive literature review of wild boar population reduction and separation methods

A.1. Search methods

Search strategies were undertaken to identify studies reporting methods for wild boar population density reduction or control and separation methods available for wild boar. Searched databases are provided in Table A.1.

Table A.1: Searched databases to identify available studies of interest

Name	Time coverage	Platform
Web of Science Core Collection	1975–present	Web of Science
BIOSIS Citation Index	1926–present	
CABI: CAB Abstracts	1910–present	
Chinese Science Citation Database	1989–present	
Current Contents Connect	1998–present	
Data Citation Index	1900–present	
FSTA – the food science resource	1969–present	
Korean Journal Database	1980–present	
MEDLINE	1950–present	
Russian Science Citation Index	2005–present	
SciELO Citation Index	1997–present	
Zoological Record	1864–present	
Scopus	1970–present	Elsevier (Scopus.com)

The searches were run on 19 February 2018. The search strategies were adapted according to the configuration of each resource of information.

The search identified 1,338 results retrieved in the Web of Science platform and 503 in Scopus. The search results were downloaded from the information sources and imported into EndNote x8 bibliographic management software. Deduplication was undertaken using a number of algorithms. The final number of results after removing duplicates was 1,352.

A.1.1. Web of Science platform[6]

Date of the search: 19/2/2018.

Limit language: Czech, Dutch, English, Estonian, French, German, Italian, Latvian Lithuanian, Polish, Romanian, Russian, Spanish.

Type of study: Article, thesis or book.

The search string used in Web of Science is provided in Table A.2.

[6] All the databases included in the Web of Science platform, as detailed in the methods section, were searched using the *All databases* search option in Web of Science.

Table A.2: Search string – Web of Science

Set	Query	Results
# 10	#7 OR #4 **Refined by: LANGUAGES:** (ENGLISH OR LITHUANIAN OR UNSPECIFIED OR GERMAN OR LATVIAN OR FRENCH OR DUTCH OR NETHERLANDISH OR RUSSIAN OR CZECH OR SPANISH OR ROMANIAN OR ESTONIAN OR POLISH OR CATALAN OR ITALIAN) AND **DOCUMENT TYPES:** (ARTICLE OR OTHER OR ABSTRACT OR CASE REPORT OR UNSPECIFIED OR REVIEW OR THESIS DISSERTATION OR BOOK) *Timespan=All years* *Search language=Auto*	1,338
# 9	#7 OR #4 **Refined by: LANGUAGES:** (ENGLISH OR LITHUANIAN OR UNSPECIFIED OR GERMAN OR LATVIAN OR FRENCH OR DUTCH OR NETHERLANDISH OR RUSSIAN OR CZECH OR SPANISH OR ROMANIAN OR ESTONIAN OR POLISH OR CATALAN OR ITALIAN) *Timespan=All years* *Search language=Auto*	1,412
# 8	#7 OR #4 *Timespan=All years* *Search language=Auto*	1,462
# 7	#6 AND #5 AND #1 *Timespan=All years* *Search language=Auto*	381
# 6	TS=(Fenc* OR barrier$ OR repel* OR restrain* OR trench* OR ditch* OR channel$ OR river$ OR ((artificial OR natural) NEAR/5 (method* OR strateg*))) *Timespan=All years* *Search language=Auto*	3,368,292
# 5	TS=(separat* OR move* OR moving OR dispers* OR (population$ NEAR/5 (structur* OR control OR management)) OR (protect* AND (field* OR farm* OR crop$ OR road$ OR highway$ OR motorway$)) OR ((prevent* OR reduc*) AND damag*)) *Timespan=All years* *Search language=Auto*	8,149,062
# 4	#3 AND #2 AND #1 *Timespan=All years* *Search language=Auto*	1,177
# 3	TS=((Population$ NEAR/5 (dynamic* OR control OR densit* OR management)) OR ((population$ OR densit*) NEAR/5 (increas* OR reduc* OR decreas* OR lower* OR limit*)) OR "de populat*" OR depopulat* OR cull* OR eliminat* OR extermin*) *Timespan=All years* *Search language=Auto*	2,162,911
# 2	TS=(gunning OR shoot* OR trap* OR snar* OR hunt* OR track* OR harvest* OR poison* OR "judas pig*" OR "judas hog*" OR feed* OR bait* OR steriliz* OR sterilis* OR chemosteril* OR (fertility NEAR/5 control*) OR (lethal NEAR/5 (method* OR strateg*))) *Timespan=All years* *Search language=Auto*	5,594,707
# 1	TS=(((pig$ OR boar$ OR swine OR hog$ OR scrofa) NEAR/5 (wild OR feral OR bush)) OR wildboar$) *Timespan=All years* *Search language=Auto*	16,045

A.1.2. Scopus

Date of the search: 19/2/2018.

Limit language: Czech, Dutch, English, Estonian, French, German, Italian, Latvian Lithuanian, Polish, Romanian, Russian, Spanish.

Type of study: Article, thesis or book.

The search string used in Scopus is provided in Table A.3.

Table A.3: Search string – Scopus

History count	Search terms	Results
9	((TITLE-ABS-KEY (((pig OR pigs OR boar OR boar OR swine OR hog OR hogs OR scrofa) W/5 (wild OR feral OR bush)) OR wildboar*)) AND (TITLE-ABS-KEY (fenc* OR barrier* OR repel* OR restrain* OR trench* OR ditch* OR channel* OR river* OR ((artificial OR natural) W/5 (method* OR strateg*)))) AND (TITLE-ABS-KEY (separat* OR move* OR moving OR dispers* OR (population* W/5 (structure* OR control OR management)) OR (protect* AND (field* OR farm* OR crop* OR road* OR highway* OR motorway*)) OR ((prevent* OR reduc*) AND damag*)))) OR ((TITLE-ABS-KEY (((pig OR pigs OR boar OR boar OR swine OR hog OR hogs OR scrofa) W/5 (wild OR feral OR bush)) OR wildboar*)) AND (TITLE-ABS-KEY (gunning OR shoot* OR trap* OR snar* OR hunt* OR track* OR harvest* OR poison* OR "judas pig*" OR "judas hog*" OR feed* OR bait* OR steriliz* OR sterilis* OR chemosteril* OR (fertility W/5 control*) OR (lethal W/5 (method* OR strateg*)))) AND (TITLE-ABS-KEY ((population* W/5 (dynamic* OR control OR densit* OR management)) OR ((population* OR densit*) W/5 (increas* OR reduc* OR decreas* OR lower* OR limit*)) OR {de-population} OR {de-populated} OR depopulat* OR cull* OR eliminat* OR extermin*))) AND (LIMIT-TO (LANGUAGE, "English") OR LIMIT-TO (LANGUAGE, "German") OR LIMIT-TO (LANGUAGE, "Spanish") OR LIMIT-TO (LANGUAGE, "French") OR LIMIT-TO (LANGUAGE, "Polish") OR LIMIT-TO (LANGUAGE, "Russian") OR LIMIT-TO (LANGUAGE, "Czech") OR LIMIT-TO (LANGUAGE, "Dutch") OR LIMIT-TO (LANGUAGE, "Romanian"))	503 document results
8	((TITLE-ABS-KEY (((pig OR pigs OR boar OR boar OR swine OR hog OR hogs OR scrofa) W/5 (wild OR feral OR bush)) OR wildboar*)) AND (TITLE-ABS-KEY (fenc* OR barrier* OR repel* OR restrain* OR trench* OR ditch* OR channel* OR river* OR ((artificial OR natural) W/5 (method* OR strateg*)))) AND (TITLE-ABS-KEY (separat* OR move* OR moving OR dispers* OR (population* W/5 (structure* OR control OR management)) OR (protect* AND (field* OR farm* OR crop* OR road* OR highway* OR motorway*)) OR ((prevent* OR reduc*) AND damag*)))) OR ((TITLE-ABS-KEY (((pig OR pigs OR boar OR boar OR swine OR hog OR hogs OR scrofa) W/5 (wild OR feral OR bush)) OR wildboar*)) AND (TITLE-ABS-KEY (gunning OR shoot* OR trap* OR snar* OR hunt* OR track* OR harvest* OR poison* OR "judas pig*" OR "judas hog*" OR feed* OR bait* OR steriliz* OR sterilis* OR chemosteril* OR (fertility W/5 control*) OR (lethal W/5 (method* OR strateg*)))) AND (TITLE-ABS-KEY ((population* W/5 (dynamic* OR control OR densit* OR management)) OR ((population* OR densit*) W/5 (increas* OR reduc* OR decreas* OR lower* OR limit*)) OR {de-population} OR {de-populated} OR depopulat* OR cull* OR eliminat* OR extermin*)))	512 document results
7	(TITLE-ABS-KEY (((pig OR pigs OR boar OR boar OR swine OR hog OR hogs OR scrofa) W/5 (wild OR feral OR bush)) OR wildboar*)) AND (TITLE-ABS-KEY (fenc* OR barrier* OR repel* OR restrain* OR trench* OR ditch* OR channel* OR river* OR ((artificial OR natural) W/5 (method* OR strateg*)))) AND (TITLE-ABS-KEY (separat* OR move* OR moving OR dispers* OR (population* W/5 (structure* OR control OR management)) OR (protect* AND (field* OR farm* OR crop* OR road* OR highway* OR motorway*)) OR ((prevent* OR reduc*) AND damag*))	125 document results
6	TITLE-ABS-KEY (separat* OR move* OR moving OR dispers* OR (population* W/5 (structure* OR control OR management)) OR (protect* AND (field* OR farm* OR crop* OR road* OR highway* OR motorway*)) OR ((prevent* OR reduc*) AND damag*))	5,030,637 document results
5	TITLE-ABS-KEY (fenc* OR barrier* OR repel* OR restrain* OR trench* OR ditch* OR channel* OR river* OR ((artificial OR natural) W/5 (method* OR strateg*)))	2,558,423 document results
4	(TITLE-ABS-KEY (((pig OR pigs OR boar OR boar OR swine OR hog OR hogs OR scrofa) W/5 (wild OR feral OR bush)) OR wildboar*)) AND (TITLE-ABS-KEY (gunning OR shoot* OR trap* OR snar* OR hunt* OR track* OR harvest* OR poison* OR "judas pig*" OR "judas hog*" OR feed* OR bait* OR steriliz* OR sterilis* OR chemosteril* OR (fertility W/5 control*) OR (lethal W/5 (method* OR strateg*)))) AND (TITLE-ABS-KEY ((population* W/5 (dynamic* OR control OR densit* OR management)) OR ((population* OR densit*) W/5 (increas* OR reduc* OR decreas* OR lower* OR limit*)) OR {de-population} OR {de-populated} OR depopulat* OR cull* OR eliminat* OR extermin*))	414 document results

History count	Search terms	Results
3	TITLE-ABS-KEY ((population* W/5 (dynamic* OR control OR densit* OR management)) OR ((population* OR densit*) W/5 (increas* OR reduc* OR decreas* OR lower* OR limit*)) OR {de-population} OR {de-populated} OR depopulat* OR cull* OR eliminat* OR extermin*)	1,577,238 document results
2	TITLE-ABS-KEY (gunning OR shoot* OR trap* OR snar* OR hunt* OR track* OR harvest* OR poison* OR "judas pig*" OR "judas hog*" OR feed* OR bait* OR steriliz* OR sterilis* OR chemosteril* OR (fertility W/5 control*) OR (lethal W/5 (method* OR strateg*)))	3,234,721 document results
1	TITLE-ABS-KEY (((pig OR pigs OR boar OR boar OR swine OR hog OR hogs OR scrofa) W/5 (wild OR feral OR bush)) OR wildboar*)	

A.2. Search results

Table A.4: Outcomes of literature review on measure to reduce wild boar population density

Reference	Methods							Method short description	Location	Area size (km^2)	Landscape	Period				Method estimation density	Reduction measure	Reported reduction statistic	Short comment
	Recreational hunting	Depopulation Hunting	Trapping	Fencing	Snaring	Fertility control	Poisoning					Start_year	Start_month	End_year	End_month				
Wild boar																			
Monzon and Bento (2004)	X							Drive hunts	Portugal, Nord, Trás-os-Montes region	12,864	Forest and agricultural land	1996	nr	2001	nr	Not reported	Hunting bag	202	The increase in corn production was the main factor involved in the increase of wild boar hunting bags
Quirós-Fernández et al. (2017)	X							Recreational hunting	Spain, Asturias	124.46	Atlantic ecosystem	2000	9	2014	2	Hunting bag	Population growth rate	0.056	Hunters are able to contribute to reduce wild boar abundance, as shown by reduced growth rate compared with period before hunting ban (but still increasing growth rate of 5.6% per year after hunting ban, despite intensive hunting)

Reference	Methods							Method short description	Location	Area size (km^2)	Landscape	Period				Method estimation density	Reduction measure	Reported reduction statistic	Short comment
	Recreational hunting	Depopulation Hunting	Trapping	Fencing	Snaring	Fertility control	Poisoning					Start_year	Start_month	End_year	End_month				
Bonet-Arboli et al. (2000)	X							Recreational hunting	Spain, Catalonia, Collserola	1	Forest and grassland	1978	nr	1999	nr	Hunting bag	Harvest rate	0.85	No calculation of population density but increasing hunting bag over the last years
Garcia-Jimenez et al. (2013)		X						Drive hunts with dogs	Spain, Central Spain, fenced estate near Madrid	30	Mediterranean ecosystem	2007		2012		Hunting bag	nr	nr	bTB prevalence remained high in the remnant wild boar population, despite increased hunting efforts. Absolute density measures were not provided
Leránoz and Castién (1996)		X						Drive hunts	Spain, Navarra	100	Forest, grassland and marshland	1987	nr	1988	nr	Hunting bag	Harvest rate	0.37	Although there has been a gradual increase in hunting bag, the proportion of the population taken by hunting was small and

Reference	Methods: Recreational hunting	Depopulation Hunting	Trapping	Fencing	Snaring	Fertility control	Poisoning	Method short description	Location	Area size (km^2)	Landscape	Period: Start_year	Start_month	End_year	End_month	Method estimation density	Reduction measure	Reported reduction statistic	Short comment
																			insufficient to keep the population at a stable number
Leránoz and Castién (1996)		X						Drive hunts	Spain, Navarra	100	Forest, grassland and marshland	1991	Nr	1992	nr	Hunting bag	Harvest rate	0.25	Although there has been a gradual increase in hunting bag, the proportion of the population taken by hunting was small and insufficient to keep the population at a stable number
Boadella et al. (2012b)		X						Drive hunts (intense and year round culling strategy)	Spain, south-central	542.52	Mediterranean ecosystem	2008	nr	2008	nr	Direct observation	Proportion removed	0.5 approximately	Culling effectively reduced tuberculosis prevalence in wild boar, while Aujeszky's disease prevalence remained unaffected. No

Reference	Recreational hunting	Depopulation Hunting	Trapping	Fencing	Snaring	Fertility control	Poisoning	Method short description	Location	Area size (km^2)	Landscape	Start_year	Start_month	End_year	End_month	Method estimation density	Reduction measure	Reported reduction statistic	Short comment
																			density estimates before and after intervention were available
Boadella et al. (2012b)		X						Drive hunts and stand hunting	Spain, south-Central	7.23	Mediterranean ecosystem	2005	nr	2011	nr	Transect	Proportion removed	0.5 approximately	Culling effectively reduced tuberculosis prevalence in wild boar, while Aujeszky's disease prevalence remained unaffected. No density estimates before and after intervention were available
Boadella et al. (2012b)			X					Capture and moving of females and juveniles	Spain, south-Central	26.9	Mediterranean ecosystem	2005	nr	2011	nr	Not available	Proportion removed	0.5 approximately	Animal removal effectively reduced Tuberculosis prevalence in wild boar, while Aujeszky's

Reference	Methods: Recreational hunting	Depopulation Hunting	Trapping	Fencing	Snaring	Fertility control	Poisoning	Method short description	Location	Area size (km^2)	Landscape	Period: Start_year	Start_month	End_year	End_month	Method estimation density	Reduction measure	Reported reduction statistic	Short comment
																			disease prevalence remained unaffected No density estimates before and after intervention were available., and trapping technique was not described
Alexandrov et al. (2011)			X					Wooden traps with wire fencing and maize baiting	Bulgaria, river Danube in the north-eastern part	25	Forest and agricultural land (maize)	2009	8	2010	1	Not reported	Harvest rate	79.00	Very efficient. Up to seven wild boar could be trapped in one trap. Feasible in areas where hunting is not recommended (viraemic animals that should not spread)
Hafeez et al. (2007)			X					Panel Trap, Fahad Trap and Loop Trap were tested	Pakistan, Faisalabad Division	nr	Forest, Grassland and Marshland	2002	nr	2002	nr		Trap efficacy	0.49–0.71	Panel trap – 70.83% efficacy Fahad trap – 48.57% Loop trap – 53.84%

Reference	Methods							Method short description	Location	Area size (km^2)	Landscape	Period				Method estimation density	Reduction measure	Reported reduction statistic	Short comment
	Recreational hunting	Depopulation Hunting	Trapping	Fencing	Snaring	Fertility control	Poisoning					Start_year	Start_month	End_year	End_month				
Feral swine																			
Saunders (1993)		X						Helicopter shooting	Australia, New South Wales, Oxley' station	120	Forest, grassland and marshland	1985	4	1985	4	Aerial surveys	Percentage population reduction	0.8	Recovery of 77% of the population after 1 year. More than one control programme should be carried out to obtain sustainable reduction
Saunders (1993)		X						Helicopter shooting	Australia, New South Wales, Oxley' station	120	Forest, grassland and marshland	1986	4	1986	4	Aerial surveys	Percentage population reduction	0.65	Recovery of 77% of the population after 1 year. More than one control programme should be carried out to obtain sustainable reduction
Gentle and Pople (2013)	X							Commercial hunting	Australia, South-western Queensland	246-6000	Mainly grassland with some forest	2007	10	2010	4	Aerial surveys	Harvest rate	0.20	Commercial harvesting is inefficient for population reduction.

Reference	Methods							Method short description	Location	Area size (km^2)	Landscape	Period				Method estimation density	Reduction measure	Reported reduction statistic	Short comment
	Recreational hunting	Depopulation Hunting	Trapping	Fencing	Snaring	Fertility control	Poisoning					Start_year	Start_month	End_year	End_month				
																			Harvest rates of > 50% are needed over several years to reduce populations
Katahira et al. (1993)		X	X		X			Drive hunts with dogs, followed by helicopter hunting, trapping and snaring	United States, Hawaii, Volcanoes National Park	78	Rainforest, Mixed	1983	11	1989	2	Transect	Proportion removed	1	Pigs were controlled primarily by drive hunts with dogs, followed by other method for remnant pigs. The mean effort needed to eradicate 175 pigs was 20 worker hours/animal. Eradication occurred in 3 years. Transect useful for monitoring population
Burt et al. (2011)		X						Drive hunts with dogs	United States, California, National park	249	Mediterranean ecosystem	1990	11	2000	3	Transect			Model based on hunting data showed that strategy of

Reference	Methods							Method short description	Location	Area size (km^2)	Landscape	Period				Method estimation density	Reduction measure	Reported reduction statistic	Short comment
	Recreational hunting	Depopulation Hunting	Trapping	Fencing	Snaring	Fertility control	Poisoning					Start_year	Start_month	End_year	End_month				
																			intense harvest for 5 years will likely achieve eradication of many insular feral pig populations
Barron et al. (2011)		X						Drive hunts with dogs	United States, Hawaii, Honomanu Makai	3	Forest	2007	10	2008	2	Capture–recapture	Proportion removed	1	Intensive hunting reduced pig abundance to zero or near-zero in most of the control zones. Reinvasion, however, was not prevented
Barron et al. (2011)		X						Drive hunts with dogs	United States, Hawaii, Waikamoi Preserve	8	Forest	2007	10	2008	2	Capture–recapture	Proportion removed	1	Intensive hunting reduced pig abundance to zero or near-zero in most of the control zones. Reinvasion, however, was not prevented

Reference	Methods							Method short description	Location	Area size (km^2)	Landscape	Period				Method estimation density	Reduction measure	Reported reduction statistic	Short comment
	Recreational hunting	Depopulation Hunting	Trapping	Fencing	Snaring	Fertility control	Poisoning					Start_year	Start_month	End_year	End_month				
Barron et al. (2011)		X						Drive hunts with dogs	United States, Hawaii, Kamakou Preserve	4	Forest	2008	3	2008	7	Capture–recapture	Proportion removed	97.00	Intensive hunting reduced pig abundance to zero or near-zero in most of the control zones. Reinvasion, however, was not prevented
Barron et al. (2011)		X						Drive hunts with dogs	United States, Hawaii, Moloka'i South Slope	10	Forest	2008	3	2008	7	Capture–recapture	Proportion removed	53.00	Intensive hunting reduced pig abundance to zero or near-zero in most of the control zones. Reinvasion, however, was not prevented
Barron et al. (2011)		X						Drive hunts with dogs	United States, Hawaii, Waikamoi Preserve	2	Forest	2008	3	2009	7	Capture–recapture	Proportion removed	89.00	Intensive hunting reduced pig abundance to zero or near-zero in most of the control zones. Reinvasion, however, was not prevented

Reference	Methods							Method short description	Location	Area size (km^2)	Landscape	Period				Method estimation density	Reduction measure	Reported reduction statistic	Short comment
	Recreational hunting	Depopulation Hunting	Trapping	Fencing	Snaring	Fertility control	Poisoning					Start_year	Start_month	End_year	End_month				
Barron et al. (2011)		X						Drive hunts with dogs	United States, Hawaii, Kapunakea Preserve	5	Forest	2008	2	2008	3	Capture–recapture	Proportion removed	65.00	Intensive hunting reduced pig abundance to zero or near-zero in most of the control zones. Reinvasion, however, was not prevented
Barron et al. (2011)		X						Drive hunts with dogs	United States, Hawaii, Waikamoi Preserve	6	Forest	2007	10	2008	2	Capture–recapture	Proportion removed	nr	Intensive hunting reduced pig abundance to zero or near-zero in most of the control zones. Reinvasion, however, was not prevented
Ditchkoff et al. (2017)		X						Not specified	United States, West-central Georgia, Fort Benning Conservation Branch	36	Coastal vegetation	2007	9	2008	2	Camera trapping	% increase density	1.1	Pig population increased during the bounty programme, mainly due to baiting and biased shooting of trophy males

Reference	Methods							Method short description	Location	Area size (km^2)	Landscape	Period				Method estimation density	Reduction measure	Reported reduction statistic	Short comment
	Recreational hunting	Depopulation Hunting	Trapping	Fencing	Snaring	Fertility control	Poisoning					Start_year	Start_month	End_year	End_month				
Ditchkoff et al. (2017)		X	X					Night hunting, trapping and bait usage allowed	United States, West-Central Georgia, Fort Benning Conservation Branch	36	Coastal vegetation	2007	7	2008	2	Camera trapping	% increase density	1.52	Pig population increased during the bounty programme, mainly due to baiting and biased shooting of trophy males
Engeman et al. (2014)		X						Not reported	United States, Florida, Avon Park Air Force Range	400	Forest, grassland and marshland	2009		2012		Passive tracking index	Reduction estimated with passive tracking index	1.00	
Gioeli et al. (2015)		X						Drive hunts	United States, Florida		NR	2013	10	2014		Hunting bag		123 removed	
McIlroy and Saillard (1989)		X	X					Trapping, hunting with dogs	Australia, Capital Territory, Orroral Valley, Namadgi National Park	11	Forest and grassland	1986	9	1986	12	Direct observation	Culling efficiency (number of animals killed per animals seen during battues)	27	The cost of hunting was c. US$312 per pig
McIlroy and Gifford (1997)		X	X					Trapping, hunting with dogs	Australia, Capital Territory, Orroral Valley area,	11	Forest and grassland	1989	6	1990		Radio-tracking	Contact rate with Judas pigs	80.00	Expensive equipment and special skills needed to precisely locate

Reference	Methods							Method short description	Location	Area size (km^2)	Landscape	Period				Method estimation density	Reduction measure	Reported reduction statistic	Short comment
	Recreational hunting	Depopulation Hunting	Trapping	Fencing	Snaring	Fertility control	Poisoning					Start_year	Start_month	End_year	End_month				
									Namadgi National Park, ACT										collared individuals. However, high efficacy to reduce population
McCann and Garcelon (2008)		X	X					Trapping, hunting with dogs	United States, California, Pinnacles National Monument	57	Forest, mixed	2003	10	2006	3	Transect	Proportion removed	100	Trapping techniques removed most pigs, but a combination of techniques was required for eradication
Reidy et al. (2011)		X	X					Box traps and helicopter hunting	United States, Texas, Fort Hood	10	Marshland	nr	nr	nr	nr	Direct observation	Proportion removed	31	2–3 weeks of trapping and 1 day of shooting swine from a helicopter resulted in removal of 31–43% of the estimated feral swine population
Reidy et al. (2011)		X	X					Box traps and helicopter hunting	United States, Texas, Rob and Bessie Welder	32	Marshland	nr	nr	nr	nr	Direct observation	Proportion removed	43	2–3 weeks of trapping and 1 day of shooting swine from a helicopter

Reference	Methods: Recreational hunting	Depopulation Hunting	Trapping	Fencing	Snaring	Fertility control	Poisoning	Method short description	Location	Area size (km^2)	Landscape	Period: Start_year	Start_month	End_year	End_month	Method estimation density	Reduction measure	Reported reduction statistic	Short comment
									Wildlife Refuge										resulted in removal of 31–43% of the estimated feral swine population
Hone and Stone (1989)		X	X					Exclusion fencing, drive hunts with dogs, trapping, snaring and baiting	United States, Hawaii, Volcanoes National Park	929	Mixed	1980	nr	1983	nr	Dung counts	nr		Pigs were eliminated from 3 of 9 management unit. Cost of removing the last animals is high
Saunders et al. (1993)			X					16 portable traps over 63 bait stations	Australia, New South Wales, Kosciusko National Park	300	Forest and grassland	1988	nr	1988	nr	Capture–recapture	Proportion removed	0.28	Local characteristics and the time of year had significant effects on trapping rate. Higher rates observed when traps placed in baiting area
Hone and Stone (1989)			X				X	2% sodium hydroxide	Australia, Namadgi National Park	910	Mixed	1985	6	1987	11	Dung counts	nr		Significant reduction of pig abundance. No poisoning effects were

Reference	Methods							Method short description	Location	Area size (km^2)	Landscape	Period				Method estimation density	Reduction measure	Reported reduction statistic	Short comment
	Recreational hunting	Depopulation Hunting	Trapping	Fencing	Snaring	Fertility control	Poisoning					Start_year	Start_month	End_year	End_month				
																			observed on non-targeted species
Anderson and Stone (1993)				X	X			Cable snares 3-96 m in length and 0.3 cm in diameter	United States, Hawaii, Kipahulu Valley, lower unit	6	Forest	1979	11	1980	3	Transect	% reduction of wild boar per km2	0.97	A mean of seven worker hours pig to remove 175 animals from the more densely populated lower unit. We recommend that transects be used in the early stages of an eradication programme to determine population density
Anderson and Stone (1993)				X	X			Cable snares 3-96 m in length and 0.3 cm in diameter	United States, Hawaii, Kipahulu Valley, Upper unit	8	Forest	1979	11	1980	3	Transect	% reduction of wild boar per km^2	0.99	A mean effort of 43 worker hours pig was used to remove 53 pigs from the upper management unit. We recommend

Reference	Methods							Method short description	Location	Area size (km²)	Landscape	Period				Method estimation density	Reduction measure	Reported reduction statistic	Short comment
	Recreational hunting	Depopulation Hunting	Trapping	Fencing	Snaring	Fertility control	Poisoning					Start_year	Start_month	End_year	End_month				
																			that transects be used in the early stages of an eradication programme to determine population density
Killian et al. (2006)						X		GnRH immune-contraceptive vaccine	United States, Florida, (controlled trial)		Captive	2002	1	2002	12	Fertility reduction	% pregnant % weight testis		Single injection effective in reducing fertility. Future research needed on residues in meat and oral form
McIlroy et al. (1989)							X	2% sodium hydroxide	Australia, Capital Territory, Namadgi National Park, Gudgenby area	225	Forest, grassland and marshland	1986	5	1986	5	Radiotracking	Proportion removed	0.91	12/14 pigs carrying transmitters died. Foxes died that fed on the corpses of the poisoned pigs
McIlroy et al. (1989)							X	2% sodium hydroxide	Australia, Capital Territory, Namadgi National Park, Boboyan Valley	140	Forest, Grassland and Marshland	1986	5	1986	5	Radio-tracking	Proportion removed	1	All pigs carrying transmitters died. Foxes died that fed on the corpses of the poisoned pigs

Reference	Methods								Method short description	Location	Area size (km^2)	Landscape	Period				Method estimation density	Reduction measure	Reported reduction statistic	Short comment
	Recreational hunting	Depopulation Hunting	Trapping	Fencing	Snaring	Fertility control	Poisoning						Start_year	Start_month	End_year	End_month				
McIlroy and Gifford (1997)							X		2% sodium hydroxide	Australia, Capital Territory, Orroral Valley area, Namadgi National Park	11	Forest and grassland	1990	10	1990	12	Radio-tracking	Proportion removed	1	All pigs followed up died of poisoning
Twigg et al. (2005)							X		Sodium fluoroacetate	Australia, Western Australia	150	Riverland and grassland	2004	8	2004	8	Direct observation	Daily sighting index	89.00	Pig activity/ abundance was reduced by 89% (81–100%) and no bait uptake by non-target species
Twigg et al. (2005)							X		Sodium fluoroacetate	Australia, North-western Australia	150	Riverland and grassland	2005	8	2005	8	Direct observation	Daily sighting index	90.00	Pig numbers had been reduced by ~ 90% within 4 days. Population recovery of 20–23% of the 2004 prebaiting level
McIlroy et al. (1989)							X		2% sodium hydroxide	Australia, Western Australia, Namadgi National Park, Orroral Valley	19	Forest, grassland and marshland	1986	5	1986	5	Radio-tracking	Proportion removed	0	None of the pigs with transmitters died

Reference	Methods							Method short description	Location	Area size (km^2)	Landscape	Period				Method estimation density	Reduction measure	Reported reduction statistic	Short comment
	Recreational hunting	Depopulation Hunting	Trapping	Fencing	Snaring	Fertility control	Poisoning					Start_year	Start_month	End_year	End_month				
McIlroy and Saillard (1989)							X	2% sodium hydroxide	Australia, Western Australia, Honeysuckle Creek area, Namadgi National Park	5	Forest and grassland	1986	9	1986	12	Radio-tracking	Proportion removed	0.14	The cost of poisoning was c. US$237 per pig
McIlroy and Saillard (1989)							X	2% sodium hydroxide	Australia, Western Australia, Orroral Valley, Namadgi National Park	11	Forest and grassland	1986	9	1986	12	Radio-tracking	Proportion removed	0.19	The cost of poisoning was c. US$237 per pig
Snow et al. (2017)							X	HOGGONE	United States, Texas, Kerr Wildlife Management Area (controlled trial)	0	nr	2015	10	2016	6	Camera trapping	Bait efficacy (%)	0.98	The bait proved lethal, acutely acting and stable in experimental conditions. Field studies needed to investigate any potential non-target risks posed by carcasses of wild pigs that have succumbed to sodium nitrite

Reference	Methods								Method short description	Location	Area size (km^2)	Landscape	Period				Method estimation density	Reduction measure	Reported reduction statistic	Short comment
	Recreational hunting	Depopulation Hunting	Trapping	Fencing	Snaring	Fertility control	Poisoning						Start_year	Start_month	End_year	End_month				
Cowled et al. (2006)							X		Sodium fluoroacetate	Australia, Welford National Park	nr	Mixed	2005	1	2005	1	nr	% reduction of wild boar per km^2	0.73	Almost all feral pigs (34 of 36) died less than 17 h after bait consumption but of non-target poisoning of other free-ranging wildlife in areas where feral pigs are baited possible not excluded

nr: not reported.

Table A.5: Outcomes of literature review on wild boar population separation methods

Reference	Method					Method description	Location	Area size (KMQ if not specified)	Landscape	Period				Method estimation effectiveness	Separation measure	Results	Short comment
	Fencing	Odour	Light	Sound	Gustatory					Start year	Start month	Stop year	Stop month				
Wild Boar																	
Santilli and Stella (2006)	X					Electric fence	Italy, Tuscany	20	Agricultural land	1999	5	2003	11	Crop damage	% crop damage reduction	93	Damage decreased of 93% during the 5 years following the fence installation
Vidrih and Trdan (2008)	X					Electric fence	Slovenia, Postojna, Western High Karst hunting territory	0.12	Agricultural land	2005	7	2005	10	Crop damage	% crop damage reduction	100	Fences were 100% successful in keeping wild boar from entering the field
Boadella et al. (2012a)	X					Fenced hunting grounds	Spain, Central Spain, Ciudad Real	19,813	Mediterranean ecosystem	1998	NR	2010	NR	Hunting bag	Effect on disease prevalence	−0.709	Risk factor analysis highlighted that the presence of the disease (*Trichinella* spp.) was lower in fenced areas ($\beta = -0.709$)

Reference	Method					Method description	Location	Area size (KMQ if not specified)	Landscape	Period				Method estimation effectiveness	Separation measure	Results	Short comment
	Fencing	Odour	Light	Sound	Gustatory					Start year	Start month	Stop year	Stop month				
Geisser and Reyer (2004)	X					Electric fence	Switzerland, Thurgau	860	Forestland and agricultural land	1994	NR	1996	NR	Crop damage	% crop damage reduction	0	Fences did not decrease the total damage rather they caused the animals to shift their activities to less protected regions in the area (+ 27% in total damage)
Sapkota et al. (2014)	X					Electric fence	Nepal, Chitwan National Park	23 km	Forestland and agricultural land	NR	NR	NR	NR	Crop damage	% crop damage reduction	78	Crop damage caused by wild boar and other wildlife were significantly reduced after the installation of the fence
Schlageter and Haag-Wackernagel (2012b)		X				Predator odour repellent	Switzerland, Basel-Land	518	Forestland and agricultural land	2007	7	2008	12	Direct observation	% effectiveness of the barrier	0.4	The odour repellent reduced the probability of wild boar visits at the luring sites by 0.4%, but the effect was not significant

Reference	Method					Method description	Location	Area size (KMQ if not specified)	Landscape	Period				Method estimation effectiveness	Separation measure	Results	Short comment
	Fencing	Odour	Light	Sound	Gustatory					Start year	Start month	Stop year	Stop month				
Schlageter and Haag-Wackernagel (2012a)		X			X	Pellets with phosphorous acid	Switzerland, Basel-Land	518	Forestland and agricultural land	NR	NR	NR	NR	Crop damage	% crop damage reduction	0	The repellent did not have a significant effect on the frequency of damages events nor it prolonged the interval between two consecutive events
Piechowski (1996)		X				Predator odour repellent	Poland, Masovian Voivodeship	0.0188	Forestland	1995	4	1995	5	Animal traces	% effectiveness of the barrier	0	A weak response of the product was reported
Piechowski (1996)		X				Predator odour repellent	Poland, Lodz Voivodeship	0.01	Forestland	1994	10	1995	5	Crop damage	% crop damage reduction	0	Different wildlife species were observed sporadically over the barrier
Piechowski (1996)		X				Predator odour repellent	Poland, Upper Silesia	3.2 km	Forestland	1994	12	1995	3	Animal traces	% effectiveness of the barrier	0	Wild boar specifically feeding signs were reported all over the barrier
Piechowski (1996)		X				Predator odour repellent	Poland, Upper Silesia	0.4 km	Forestland	1994	12	1995	3	Animal traces	% effectiveness of the barrier	0	Wild boar were observed all over the barrier

Reference	Method					Method description	Location	Area size (KMQ if not specified)	Landscape	Period				Method estimation effectiveness	Separation measure	Results	Short comment
	Fencing	Odour	Light	Sound	Gustatory					Start year	Start month	Stop year	Stop month				
Piechowski (1996)		X				Predator odour repellent	Poland, Warmian-Masurian	0.01	Forestland	1994	10	1995	5	Crop damage	% crop damage reduction	1.6	Reported damage were caused by different wildlife species
Wegorek and Giebel (2008)		X				Human odour repellent	Poland, Wielkopolskie	0.01	Agricultural land	2007	5	2007	5	Crop damage	% crop damage reduction	55	The repellent was effective in keeping the animals away from the crops, even if a certain grade of accustoming was recorded
Wegorek and Giebel (2008)		X				Human odour repellent	Poland, Voivodeship	0.01	Agricultural land	2007	8	2007	9	Crop damage	% crop damage reduction	65	The repellent was effective in keeping the animals away from the crops, even if a certain grade of accustoming was recorded
Wegorek and Giebel (2008)		X				Human odour repellent	Poland, Voivodeship	0.002	Forestland	2007	3	2007	4	Crop damage	% crop damage reduction	55	The repellent was effective in keeping the animals away from the crops, even if a certain grade of accustoming was recorded

Reference	Method					Method description	Location	Area size (KMQ if not specified)	Landscape	Period				Method estimation effectiveness	Separation measure	Results	Short comment
	Fencing	Odour	Light	Sound	Gustatory					Start year	Start month	Stop year	Stop month				
Wegorek and Giebel (2008)		X				Predator odour repellent	Poland, Wielkopolskie	0.01	Agricultural land	2007	8	2007	9	Crop damage	% crop damage reduction	100	The repellent was effective in keeping the animals away from the crops
Wegorek and Giebel (2008)		X				Predator odour repellent	Poland, Wielkopolskie	0.01	Agricultural land	2007	5	2007	5	Crop damage	% crop damage reduction	100	The repellent was effective in keeping the animals away from the crops
Wegorek and Giebel (2008)		X				Predator odour repellent	Poland, Wielkopolskie	0.01	Agricultural land	2007	5	2007	5	Crop damage	% crop damage reduction	100	The repellent was effective in keeping the animals away from the crops
Wegorek and Giebel (2008)		X				Predator odour repellent	Poland, Wielkopolskie	0.002	Forestland	2007	3	2007	4	Crop damage	% crop damage reduction	85	The repellent was effective in keeping the animals away from the crops
Wegorek and Giebel (2008)		X				Predator odour repellent	Poland, Wielkopolskie	0.01	Agricultural land	2007	8	2007	9	Crop damage	% crop damage reduction	100	The repellent was effective in keeping the animals away from the crops
Wegorek and Giebel (2008)		X				Predator odour repellent	Poland, Wielkopolskie	0.002	Forestland	2007	3	2007	4	Crop damage	% crop damage reduction	90	The repellent was effective in keeping the animals away from the crops

Reference	Method					Method description	Location	Area size (KMQ if not specified)	Landscape	Period				Method estimation effectiveness	Separation measure	Results	Short comment
	Fencing	Odour	Light	Sound	Gustatory					Start year	Start month	Stop year	Stop month				
Wegorek et al. (2014)		X				Human odour repellent	Poland, Wielkopolskie	NR	Forestland and agricultural land	2012	3	2013	8	Direct observation/ animal traces	% effectiveness of the barrier	0	The product has proven to be not effective
Wegorek et al. (2014)		X				Odour repellent	Poland, Wielkopolskie	NR	Forestland and agricultural land	2012	3	2013	8	Transect	% effectiveness of the barrier	0	The product was effective only for a 2–3 days period, then the animals get used to it
Wegorek et al. (2014)		X				Human odour repellent	Poland, Zachodniopomorskie	NR	Forestland and agricultural land	2012	3	2013	8	Direct observation/ transect	% effectiveness of the barrier	0	The product has proven to be not effective
Wegorek et al. (2014)		X				Odour repellent	Poland, Zachodniopomorskie	NR	Agricultural land	2012	3	2013	8	Transect	% effectiveness of the barrier	0	The product was effective only for a 2–3 days period, then the animals get used to it
Bil et al. (2018)		X				Isovaleric acid odour repellent	Czech Republic	1936 m	Road section	2014	9	2016	10	Carcasses/ crash reported	% crop damage reduction	26-43	The reduction of WVC was 26–43%; therefore, the odour repellent helps to mitigate the number of accidents

Reference	Method					Method description	Location	Area size (KMQ if not specified)	Landscape	Period				Method estimation effectiveness	Separation measure	Results	Short comment
	Fencing	Odour	Light	Sound	Gustatory					Start year	Start month	Stop year	Stop month				
Sakthivel et al. (2013)		X				Ricinolic acid odour repellent	India, Telangana, Hyderabad	0.000016	Agricultural land	NR	NR	NR	NR	Crop damage	% crop damage reduction	100	After the repellent treatment, no damage was recorded despite the presence of the animals around the crops
Schlageter and Haag-Wackernagel (2011)			X			Solar blinkers near luring sites	Switzerland, Basel-Land	518	Forestland and agricultural land	2007	1	2005	1	Camera trapping	% effectiveness of the barrier	8.1	Blinkers reduced the probability of wild boar visits at the luring sites by 8.1% but the effect was not significant
Dakpa et al. (2009)			X	X		Shrill electrical sound and bright light	Bhutan	NR	Agricultural land	2008	5	2009	2	Crop damage	% crop damage reduction	67	The device is effective when functioning smoothly. It is recommended as short-time measure
Feral Pigs																	
Lavelle et al. (2011)	X					Hog panel mesh	United States, Texas, Kingsville	0.0038	Grassland	2009	7	2009	9	Direct observation	% effectiveness of the barrier	96.7/ 83/100	Hog panel fences were estimated to be 96.7 effective if humans entering the enclosures,

Reference	Method					Method description	Location	Area size (KMQ if not specified)	Landscape	Period				Method estimation effectiveness	Separation measure	Results	Short comment
	Fencing	Odour	Light	Sound	Gustatory					Start year	Start month	Stop year	Stop month				
																	83% if humans walking discharging paintball projectors and 100% effective when the animals were pursued by gunners in a helicopter
Reidy et al. (2008)	X					Electric fence, agriculture trial	United States, Texas, King Ranch	24.35	Agricultural land	2006	5	2006	6	Crop damage	% crop damage reduction	64	The mean percentage of crop damage at harvest was 64% less for electric fence treatments than controls
Reidy et al. (2008)	X					Electric fence, rangeland trial	United States, Texas, San Patricio County, Sinton	31.57	Marshland	2006	3	2006	4	Camera trapping	% intrusion reduction	49/26	Mean number of daily intrusions by pigs during the period with electrified fence were 49% less than during period without electric fence, and 26% less than during period after electrification (non-electrified fence)

Reference	Method					Method description	Location	Area size (KMQ if not specified)	Landscape	Period				Method estimation effectiveness	Separation measure	Results	Short comment
	Fencing	Odour	Light	Sound	Gustatory					Start year	Start month	Stop year	Stop month				
Reidy et al. (2008)	X					Electric fence, captive trial	United States, Texas, Kleberg County, Kingsville	0.0051	Artificial environment	2005	10	2005	11	Camera trapping	% effectiveness of the barrier	65/69	The mean number of crosses during the period without electric fencing was 65% greater than the period with electrified fence and 69% greater than the period after electrification (non-electrified fence)
Schmidt (1986)	X					Electric fence	Indonesia, West Sumatra	0.32	Agricultural land	NR	NR	NR	NR	Farmer surveys/direct observation	% effectiveness of the barrier	100	After the fencing installation, no feral pigs entered the protected area, despite their presence around the crops
Jeyasingh and Davidar (2003)	X					Electric fence	India, Tamil Nadu, Kalakad-Mundanthurai Tiger Reserve	26 km	Forestland and agricultural land	1998	12	1999	3	Farmer surveys	% crop damage reduction	0	No significant difference in the loss estimates, raiding frequency and wild boar group size between the fenced and unfenced villages

NR: not reported.

Appendix B – ASF timeline in the Czech Republic (situation 3.4.2018)

21 June 2017 – ASF has been suspected in a dead found wild boar in the Municipality of Zlin, District of Zlín, Region of Zlín close to the local hospital.

26 June 2017 – ASF confirmed through Laboratory investigation.

27 June 2017 – A wild boar-infected area has been established. The infected area is the whole district of Zlín (1034 km2, 37 municipalities, 89 hunting grounds).

13 July 2017 – Intensive hunting in a buffer area around the infected area.

18 July 2017 – The infected area has been divided into two subareas: high-risk (including a higher risk fenced area) and low-risk infected subareas.

21 July 2017 – Hunting allowed in the low risk sub-area of the infected area.

11 September 2017 – Individual hunting allowed in the high-risk subarea including the fenced subarea.
In both areas, only trained hunters are allowed to hunt prey. All hunted animals are collected in designed wild boar collecting points, safely dispatched to the rendering plant, sampled by an official veterinarian and disposed.

16 October 2017 – Hunting by police in the high-risk area. Hunting by snipers from police started. Hunted in total 157 wild boar hunted and eight of these were positive for ASF. Snipers were trained for wild boar hunting and for biosecurity during hunting. Police snipers were employed in the high-risk zone. They were split in eight teams of two men shooting wild boar at 3 days interval. All shot wild boar were collected by State veterinary administration, safely transported to the nearest road and then sampled at the rendering plant.

Appendix C – The effect of hunting efforts in Estonia

Table C.1: Effect of hunting efforts to wild boar population structure in Estonia (tested animals 2015–2017)

Year 2015	Female		Male		Total	
	n	%	n	%	n	%
Found dead						
piglets	115	60%	75	40%	190	34%
Subadults	102	57%	77	43%	179	32%
Adults	112	60%	73	40%	185	33%
Total	329	59%	225	41%	554	100%
Hunted						
Piglets	1,371	52%	1,275	48%	2,646	33%
Subadults	1,440	51%	1,394	49%	2,834	36%
Adults	1,202	49%	1,231	51%	2,433	31%
Total	4,013	51%	3,900	49%	7,913	100%
Year 2016	**Female**		**Male**		**Total**	
	n	**%**	**n**	**%**	**n**	**%**
Found dead						
Piglets	120	61%	76	39%	196	35%
Subadults	96	63%	57	37%	153	28%
Adults	129	63%	77	37%	206	37%
Total	345	62%	210	38%	555	100%
Hunted						
Piglets	2,986	48%	3,191	52%	6,177	43%
Subadults	2,064	57%	1,566	43%	3,630	26%
Adults	2,461	56%	1,959	44%	4,420	31%
Total	7,511	53%	6,716	47%	14,227	100%
Year 2017	**Female**		**Male**		**Total**	
	n	**%**	**n**	**%**	**n**	**%**
Found dead						
Piglets	47	69%	21	31%	68	32%
Subadults	37	57%	28	43%	65	31
Adults	43	54%	36	46%	79	37%
Total	127	60%	85	40%	212	100%
Hunted						
Piglets	1,428	42%	1,931	58%	3,359	38%
Subadults	1,405	55%	1,154	45%	2,559	29%
Adults	1,486	51%	1,422	49%	2,908	33%
Total	4,319	49%	4,507	51%	8,826	100%

Table C.2: Prevalence of ASFV DNA-positive animals among tested hunted wild boar in Estonia in 2017 in the area infected in years 2014 and 2015 compared with the area infected in 2016

Year of infection	County	Tested	Positive	
		n	n	%
2016	Harju maakond	860	45	5.2%
	Laane maakond	1,643	54	3.3%
	Parnu maakond	834	22	2.6%
	Rapla maakond	332	11	3.3%
	Laane-Viru maakond	328	14	4.3%
	Saare maakond	2,487	104	4.2%
	Total (CI 95%)	6,484	250	3.9% (3.4...4.4)
2014–2015	Tartu maakond	164	1	0.6%
	Valga maakond	101	0	0.0%
	Viljandi maakond	119	0	0.0%
	Ida-Viru maakond	336	2	0.6%
	Jarva maakond	62	0	0.0%
	Jõgeva maakond	76	0	0.0%
	Põlva maakond	58	1	1.7%
	Võru maakond	147	2	1.4%
	Total (CI 95%)	1,063	6	0.6% (0.3...1.2)
Grand total (CI 95%)		7,547	256	3.4% (3.0...3.9)